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PLANT SCIENCES IN THE SHEFFIELD SCIENTIFIC SCHOOL[1]

By Professor RUSSELL H. CHITTENDEN
YALE UNIVERSITY

As a noted English scientist, Sir Walter Fletcher, has said recently, "In the field of research the whole body of knowledge has been advancing so fast that the individual workers, at their various points on its growing borders, are in danger of becoming so far separated one from another in the very course of their advance as to lose the fertility that comes from the easy exchange of ideas and methods." Hence, the value of such gatherings as this, by which workers in specialized fields can compare methods and results, gain perhaps added enthusiasm and encouragement, and go forth with renewed vigor in the prosecution of their own particular studies.

As a physiological chemist I like to think in broad terms of physiology as a study of the functions of living organisms, animal and vegetable; a study of the functions of living matter irrespective of its origin. Differentiation of these functions, as we all know, is determined largely by the character of the methods that have to be followed in their study. Thus, we emphasize chemical physiology and physical physiology mainly because the functions concerned are explainable by chemical laws or by physical laws, their study involving on the one hand the intricate methods of the chemist, while on the other the methods of the physicist are called for. Again, we stress the terms animal and plant physiology, recognizing thereby the innate differences in function characteristic of the two forms of life, understanding full well that in the higher forms individual functions can be studied successfully only by different technical methods applicable to each type. If we talk about physiological chemistry or biochemistry we are giving expression to the fact that owing to deepening knowl-

[1] An address delivered at the Conference for Investigators Interested in the Chemistry and Physiology of Plants, at New Haven, Connecticut, June 5, 1931.

edge there is a large accumulation of chemical data of the greatest physiological importance and significance which chemistry has been, and still is, making available. Such data have value largely as they throw light on, and help explain, physiological processes.

While to-day knowledge of plant physiology has progressed so far as to cover a wide field, with trained workers constantly contributing new facts and theories based on experimental work of diverse character, it may not be amiss to look back to the days of simple things, when in this country experimental work—laboratory work—was almost an unknown quantity. It is worth remembering that the first laboratory of physiology for the use of students in the United States was established in 1871 at the Harvard Medical School, while the first laboratory of physiological chemistry for instruction and research in this country was started here at Yale, in the Sheffield Scientific School, in 1874. In this same year, Sir Michael Foster, at that date a young instructor in University College, London, began the teaching of practical physiology and rudimentary physiological chemistry in England, his being the first laboratory course in these subjects offered in that country.

From these statements it is obvious that experimental work in physiology could have had few followers fifty years ago in the United States. Chemical laboratories, however, were much more numerous, and experimental work along chemical lines was gaining rapid headway at various educational centers, and consequently such work as had been attempted in plant physiology was essentially of a chemical character. Here at Yale the first appointment made in plant physiology was in 1846, at the time when what is now the Sheffield Scientific School was started. The incumbent of the professorship then established was John Pitkin Norton, and the appointment read "professor of agricultural chemistry and animal and plant physiology." It is apparent from the title that he was in reality professor of scientific agriculture, but his training in chemistry and in botany had been unusually broad and thorough for those days. For several years he had worked in chemistry at Yale with Silliman and he had spent one year at Harvard. After this preliminary training, he was two years with Professor Johnston in the laboratory of the Agricultural Chemical Association at Edinburgh and a year in the laboratory of Professor Mulder at Utrecht. Probably no American at that date had ever enjoyed such opportunities for scientific training in agriculture as he had experienced.

While abroad, he had made several contributions—the result of original work—to the British Association at Cambridge which had attracted much favorable comment. Most noteworthy was his study of the oat presented to the Highland Agricultural Society of Scotland, for which he received the prize of fifty sovereigns offered for the best piece of work on the subject. This paper was republished in the *American Journal of Science*, its scope being indicated by the following quotation: "Commencing with the young plant, he followed it through its successive stages of growth and development to its maturity, the many analyses giving the composition of the oat from the different parts of the plant separately, *viz.*, the leaf above and below, the stalk, the knots, the grain, etc., besides the organic constituents of the grain." This without doubt was the most thorough chemical investigation of the oat ever made up to that date.

Norton came to New Haven with the expectation that he would be able to devote much of his time and energy to original investigation, for which he was so admirably fitted, but on returning to America he found himself obliged to play the part of a pioneer if he would help forward the development of scientific agriculture in this country. Unfortunately after five years of arduous work his career was suddenly closed by death.

Norton's successor in the Scientific School was John Addison Porter, appointed in 1852. He was a graduate of Yale, and he had enjoyed a long training in chemistry and physiology under Liebig, so that he had a high appreciation of the importance of agricultural chemistry and its application in the cultivation of crops.

More significant in a way was the appointment in 1856 of Samuel W. Johnson, who had worked for a long period with Liebig, his title being professor of analytical and agricultural chemistry. For many years he gave an annual course of lectures to graduate and undergraduate students of the Sheffield Scientific School upon agricultural chemistry and the physiology of plants. This course of lectures attracted so much attention both here and abroad that he was invited to deliver a course of lectures on these subjects in Washington, at the Smithsonian Institution. Later, in 1868, much of this material was brought together in book form under the title "How Crops Grow," dealing particularly with the chemical composition, structure and life of the plant. This book was followed two years later, 1870, by "How Crops Feed," which likewise gained wide attention. As an illustration of the great value of these two books it is only necessary to add that they were translated into German, Swedish, Russian and Japanese, while the first was also translated into Italian.

Johnson was not preeminent as an investigator. His strength lay in his breadth of knowledge, critical judgment and keen analytical mind, which fitted him well for the service he felt called upon to perform,

viz., the development of truly scientific methods for the advancement of agriculture. He was, as you doubtless know, the father of the agricultural experiment stations in this country, and his influence in agriculture was dominant for many years. Such original work as he carried on in the field of plant physiology had to do mainly with the fixation of ammonia, nitrification and the assimilation of complex nitrogenous bodies by vegetation. I recall a paper published in 1866 which dealt with the nutrition of plants, where, by feeding, under suitable conditions, uric acid, hippuric acid and hydrochlorate of guanine, he found that such amides resulting from the disorganization of protein compounds, as well as ammonia salts and nitrates, are capable of direct passage into the plant and there serve for the reorganization of albumen, etc.

I must also refer to William H. Brewer, who like Johnson was an early graduate of the Sheffield Scientific School and who for nearly forty years (1864–1903) was professor of agriculture here. A student of botany at Heidelberg and of chemistry with Bunsen, later with Liebig at Munich, a student of both sciences at Paris, he was broadly trained in the sciences underlying agriculture. Further, from 1860 to 1864 he was associated with J. D. Whitney on the first scientific survey of California, making a special study of the flora of the state, the results of which were published at Cambridge in conjunction with Sereno Watson in 1876, under the title "The Polypetalae." Brewer was a connecting link between chemistry, botany and forestry for many years and while he did no original work in plant physiology he was one of the influences here that helped to arouse interest in the sciences upon which scientific agriculture depends.

Also connected with this earlier generation was Daniel C. Eaton, professor of botany in the Sheffield Scientific School from 1864 to 1895. An enthusiastic worker in his chosen field, he trained many men in botany who like their teacher were interested primarily in structure and classification rather than in plant physiology.

It may seem somewhat foreign to the interests of this group of workers to recall these men of earlier times, for they were not, strictly speaking, what we should call to-day students of plant physiology, yet they created an atmosphere here favorable for the growth of knowledge contributory to a clearer understanding of physiological problems in relation to plant life and growth. It was natural in this new country that plant physiology should develop gradually from studies related to scientific agriculture. Successful agriculture was dependent upon the growth of the crops. If the crops failed it meant disaster to the farmer and to the community, while increase in yield frequently meant prosperity. Naturally, therefore, attention was focused largely upon studies which promised help in securing a rich crop, and it was the work of the chemist that was called for mainly.

As time went on, however, there gradually developed a more scientific spirit, study for the sake of truth, the gaining of knowledge to broaden the understanding of nature's ways without regard to practical application. To-day, the study of plant life by chemical and physical methods is yielding a rich harvest, but in Germany, for example, we look back to such men as Liebig and Ritthausen, from whom in the earlier years came the inspiration and the stimulus upon which present-day progress is more or less dependent, and in this country we may well glance backward to the early workers in chemistry, botany and agriculture who were likewise helpful in preparing the way for the advances in knowledge witnessed in this generation.

No better illustration of the scientific value of study and research for the sake of increasing knowledge can be found than in the work of Thomas B. Osborne, during the years 1886–1928, as research chemist at the Connecticut Agricultural Experiment Station. His life, as you know, was devoted almost entirely to studies in protein chemistry, especially proteins of vegetable origin, his interest in this subject having been stimulated in part by Professor S. W. Johnson. To Osborne and his coworkers we owe much of our present-day knowledge regarding the chemical character and composition of the proteins of different plants, the partition of nitrogen and more specifically the proportion of the various amino-acids present in different vegetable proteins. Especially noteworthy was his work carried on with H. Gideon Wells, on the anaphylaxis reaction as a means of establishing chemical identity, resulting among other things in the conclusion "that each seed contains several chemically distinct proteins, and that no two seeds, unless very closely related botanically, contain chemically identical proteins."

Equally interesting was the conclusion that there must be an almost infinite variety of vegetable proteins, the anaphylactogenic property of a protein being determined by its chemical structure and not by its biological origin. Again, the researches of Osborne and Mendel on the nutritive value of the vegetable proteins have contributed largely toward establishing the close relationship between the chemical constitution of the proteins and their biological value. We have come to see that growth in the animal body is dependent upon the presence in the food of certain amino-acids, such as lysine, cystine and

tryptophane, these being imperatively needed for the building of tissue and for making good the losses of cellular material. Hence, proteins which are lacking in these indispensable amino-acids, or contain them only in small amounts are physiologically inferior proteins, not fitted to meet the needs for proper growth.

But I must not continue longer. To cultivate research and thus promote the advancement of knowledge, to bring to light a new truth, in whatever the field of endeavor, is to the true scientist one of the great joys of life. As a recent writer (A. V. Hill) has expressed it: "In scientific research we work and work, sometimes for months and years, in digging a tunnel with no apparent results; then suddenly comes the supreme joy of life—daylight begins to glimmer at the end, and in a few minutes we see that nature, after all, has not played us false."

THE NEED OF COOPERATION IN BIOCHEMICAL RESEARCH[1]

By Professor TREAT B. JOHNSON
YALE UNIVERSITY

A CONTINUOUS teaching and research contact with scientific workers in an academic atmosphere, such as has prevailed at Yale for the last thirty years, is an experience not to be enjoyed by many teachers. An active man could hardly fail to have been influenced by what has happened within this period of time, and also benefited by the many associations that such a professional career offers. It has been the writer's good fortune to have enjoyed such an experience, and he is not able to properly express his appreciation for the satisfaction and pleasures which he has enjoyed in many ways during the past thirty-one years through his associations with graduate students and cooperative undertakings, in the promotion of Yale's activities and productions in chemical research. Although it is nearly one third of a century, it has all happened so quickly that it is difficult to realize the significance of the advances that have been made in our knowledge of the field of chemical science and to comprehend the possibilities of discovery in the newer fields of research which have been opened up to the organic chemist within this period of time. There is no doubt that the younger men who have in their control the destinies of the next thirty years of scientific service have before them opportunities for successful accomplishments which are just as promising as the future held out to young investigators at the beginning of this century. We older men do not begrudge these new recruits to our ranks their rich opportunities, but we wish them the best of success, and with the hope that our accomplishments of the past thirty years will have made their course less difficult to follow, their problems easier to understand, and their methods of attack and conclusions more exact and definite.

[1] An address delivered at the Conference for Investigators Interested in the Chemistry and Physiology of Plants, at New Haven, Connecticut, June 5, 1931.

The last half century has seen a great advance, not only in the development of every branch of the natural sciences, but also in the number of these branches. It has been a growth which has necessarily led to much specialization, but not without great benefit to all the major divisions of the natural sciences.

The names of the new sciences, for example, such as geochemistry, biophysics, biochemistry, astrophysics, psychophysics, and many others, which we have not time to mention here, show that these new subdivisions are merely the overlapping of two or more of the older branches of science. Their fields of operations are the border lines of different sciences where the phenomena of natural interest are dependent on fundamental laws characterizing the special sciences involved. What has been the result of this overlapping?

(1) One result has been a breaking down of the old boundaries of science and a more general recognition of the scope and application of the theories and principles of the science of chemistry. To-day there is no definite boundary between chemistry and physics, between chemistry and crystallography, between chemistry and metallurgy, or between chemistry and technology.

(2) It has meant also that we have developed a highly specialized knowledge which now requires a much broader basis of scientific training than it did thirty years ago. As a result we have been called upon to give more thoughtful consideration to the preliminary training of those who desire to prepare themselves for professional careers and to pay more attention to the proper coordination of fundamental course subjects and to emphasize the dual nature of the major scientific projects now calling for investigation and solution.

(3) And, finally, it has caused to be evolved a new

program or era of sympathy, understanding, general appreciation of the importance of all research and interchange of ideas between workers in different fields of science. No scientific group of workers can live to-day within itself and accomplish its best work. We are all more or less interdependent and we are living in an age which is changing rapidly, and quick decisions are expected. This urgent demand for prompt solution and more rapid progress is calling for increased concentration on the part of the investigator and a greater amount of cooperation than ever before. Closer organization seems to be the demand of our times, and the bringing together of different workers in the fields which overlap is essential if we are to accomplish our best work.

No science has been more affected in the scope of its interest by these developments than chemistry. The specialized subdivisions of knowledge, such as biology, bacteriology, animal and plant physiology, botany, pharmacology, medicine, surgery, psychology and even some subdivisions of the social sciences, can no longer dissociate themselves from its influences. Chemistry was once confined to a few individuals and used in a few industries only. It is now widely diffused in all scientific undertakings dealing with natural phenomena and is used in practically every industry. No one can study to-day any modern science or branch of technology, mathematics alone excepted, without some knowledge of chemistry. In fact, in a few years' time every person that is considered properly educated will have a smattering of chemistry, and furthermore, no chemist will attempt to be interested and informed in all the several branches of chemistry. Procedures that have suited in the last fifty years will require much modification to meet the growing demands and to suit the next fifty years.

The technical and scientific world was never more interesting to investigators and the public than it is to-day. Discovery follows closely on the heels of discovery; theories and speculations live only for a short time. Industry to-day is in a state of constant strain. Processes that lead to a financial success to-day become impractical or obsolete to-morrow. In the hands of the engineer or technologist lies the secret to-day of success in all our industrial enterprises. Every discovery depends upon previous work. Every stage in the unfolding of knowledge prepares the way for further advance.

The most outstanding development in the biological sciences, from a biological or a chemical point of view, has been the growth of that field of scientific endeavor that we include to-day under the subdivision "biochemistry." It was not, however, until workers in the different biological subdivisions began to realize what chemistry could do to aid in the advancement of the knowledge of their respective subjects that cooperative measures were finally instituted, which led up to the important developments grouped under this new branch of science.

That all vital activity is dependent on chemical reactions is a belief which has influenced the growth of organic chemistry for years. Chemists have been interested for a long time in elucidating the chemical mysteries of the living processes of animals and plants. The French chemist, Lavoisier, in the eighteenth century was one of the first to express an interest in the phenomenon of respiration, and he stated that animal heat results from the action of oxygen. As a result of his postulations the direct method of oxidation was thought for a long time to be the only one to which the phenomenon of respiration could be ascribed. Later, this conception of respiration and fermentation was shown to be untenable when Pasteur, a chemical-bacteriologist, demonstrated that microorganisms could exist and propagate their form without free oxygen. In fact, he went so far as to show that oxygen acted as a poison and was harmful to some of the lower forms of life. We now recognize as a result of his work that this gas must be excluded if anaerobic organisms are to grow and multiply. In fact, Pasteur regarded fermentation as anaerobic phenomenon. To-day these pioneer conceptions of respiration phenomenon no longer hold. Our ideas have been revolutionized by the new discoveries in biochemistry revealing a more exact understanding of cellular oxidation-reduction changes. This has been the result of three broad chemical influences: (1) A better understanding of the chemical composition of cells and their process of metabolism; (2) an advance in our knowledge of the physical chemistry of organic reactions in heterogeneous systems and the experimental conditions affecting intermolecular transformations; and (3) the discovery of the fundamental laws governing all colloidal and interfacial phenomena.

Emil Fischer's classic contributions to our knowledge of the chemistry of proteins and sugars, van't Hoff and Le Bel's brilliant speculations which led up to the modern physical conception of the asymmetry of carbon in organic combinations, and the recent revelations of organic structure and crystal constitution by application of x-ray photography are illustrative examples of the many classic contributions to chemical science which have finally established firmly the architectural theory of the molecular structure of organic compounds. Every branch of natural science which has called upon organic chemistry for cooperation in the development of its border-line problems has been influenced by this structure theory conceived by the early workers in chemistry. The

theory of organic structure has been fully substantiated and it has stood the test of experimental science for the past sixty years. It is now recognized as being in complete accord with the exactness, precision and regularity of all natural biological phenomena.

In other words, chemical-biology, or biochemistry, has assumed a particular distinction to-day as a field of science which gives it a much broader significance and scope of operations than can be ascribed to any single subdivision of science. It represents in modern language a community of scientific interests having interdependent relations, and no one of the fields of study embraced under this term can function to-day independently.

We can, therefore, no longer divorce chemical from biological reasonings. All the branches of biological science are becoming more and more closely connected with the facts and theories of chemistry as new discoveries are made and our technique is improved.

If it be admitted that this consolidation of chemical and biological interests is necessary for future growth, and will lead to an increase in our knowledge of natural phenomena, is it not a logical conclusion that the future workers in these related fields should be urged to cooperate more closely in their work, and seek to better understand the view-points of each other—in other words to be able to think and reason together? The contact can not be otherwise than helpful. Professor George Barger, of Edinburgh, Scotland, remarked in a recent address as follows: "I am convinced that within the limits of administrative possibility the greater the variety of workers brought together the better the results." This is most essential to-day if different workers in two or more correlated scientific fields are not to be deprived of much valuable interchange of ideas, of essential materials for experimentation and new apparatus for developing technique.

This does not mean that the discoveries made by individual and isolated workers who desire or are compelled to work alone will be without value in the final solutions of our many problems. We all know that we have scientific workers who are so constituted that they can do their best work independently and will be exceptionally brilliant and capable of contributing largely to knowledge oftentimes in more than one scientific field. Nothing should be done to interfere with or restrict the activities of such investigators. They represent an important unit of our scientific personnel, and many of our soundest conclusions are made under such conditions.

One could expand further on the subject of all-around genius, and of the few men who are able to make discoveries of far-reaching effect in whatever branch of science they took up. Notwithstanding all this, it is undoubtedly true that the amount of scientific data made available by such men will be much smaller and less comprehensive than that which is contributed by workers organized on a cooperative basis. This has been well illustrated by what has been accomplished within the last six years in the field of tuberculosis research, and many other illustrations could be given to support our thesis.

A biochemist requires to-day a thorough grounding in physiology and organic, physical and colloid chemistry as well as some acquaintance with diverse subjects like botany, and even pathology. In fact, the important problems calling for solution to-day demand a close cooperation between chemical laboratories, plantations, forest and field, and require the services of men of considerable intellectual ability, a capacity for careful and sustained observations, and ability to select data with good judgment and a liking for life in open competition.

It is significant that at the present time a steadily increasing number of trained organic chemists consider it worth their while to turn to biochemistry for their future work. They are apparently welcomed into the ranks of such service, and the future holds much in store for them. The development of chemistry in elucidating the mysteries of living plants and animals is the most attractive field of research for the next generation.

Our future investigations will involve the inner structure of matter, radioactivity phenomena, nature of magnetism, utilization of electrical charges, conversion of these into heat and their effect on life itself. Progress will be made if our educational system will enable us to develop researchers of intelligence, gifted with the ability to observe, who have a good eye and show skill in manipulation.

A great deal is known about the biochemistry of the body, but a great deal is obscure. At present the line of progress seems to lie in the isolation, identification and subsequent synthesis of products produced by cells of the body and plant. But how much is actually known about the chemical activities of the vital source of biological phenomena—the living cell? We all realize that we are dealing here with delicate problems, but we are optimistic about the future results. The chemical compounds regulating animal life are being slowly and surely identified and the chemical processes they cause are now being watched and explained. The chemistry of bacteriology, of simple botanical life, of fermentation, of drugs and alkaloids useful for treatment of disease and enzymic processes now form some of the important branches of the science of biochemistry.

To summarize: Just as chemistry has permeated

every industry, so it has permeated practically every fundamental science. In fact, it is not improbable that it may cease to exist as a separate science, just as reading, grammar and arithmetic have ceased to enjoy independent existence. As a result of further cooperation between subdivisions of science, science itself may perhaps become one subject. We shall then attain the final objective of all scientific effort.

INDUSTRIAL SCIENCE—A GILT EDGE SECURITY[1]

By MAURICE HOLLAND

DIRECTOR, DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH, NATIONAL RESEARCH COUNCIL

RESEARCH is one of the best forms of security for capital invested in industry. Efficient management is another. To a trained observer there is a direct relation between the research rating and the security ranking of the leaders of American industry. Turn to the financial page of your paper and read the names of industrial companies known as market leaders and you will find a list of those companies best known for their extensive research activities. Nowadays the discoveries of science is front-page news. The applications of science in industry appear in the business section, while the latest report of the advances of industrial technology are reflected in the quotations on the Stock Exchange. In the language of Wall Street, science appears on the financial page, when "the news is out."

Headlines that tell you of the latest happenings in the scientific world are primarily written, not to report the possibilities of prospective increases in profits or dividends, but to acquaint the whole public with facts that picture the march of progress. The science story appears on the front page for the reason that the achievements in the field of pure science are changing the face of the world. The story of what our scientists are doing and how they are doing it is much more than a story of financial success. On the contrary, it is fundamentally a story of advancing civilization, of higher standards of living, increased comforts, better health, easier working conditions, more leisure, in fact, of all the things that lead to the betterment of mankind.

One of the most widely read financial magazines circulates a questionnaire periodically to a fixed list of about 1,000 business leaders made up of presidents and presiding officers of corporations whose stocks are listed on the New York Stock Exchange. The winners in the most recent poll of corporation executives places the companies in this order: American Telephone, United States Steel, General Electric, Standard Oil, General Motors, Anaconda Copper, Electric Bond and Share, United Corporation, Radio Corporation, Westinghouse Electric and Manufacturing. A list of "Who's Who of Science in Industry" would contain the same names, with the exception of United Corporation, a holding company. The research activities of these companies have put them in first position, among the leaders of American industry, and research enables them to maintain that position.

In the highly competitive struggle for industrial supremacy, the march of science, discovery and invention has so speeded up the advances of technology that a laboratory discovery may mean creation of a new industry, or expansion of one and losses for another. To-day's discovery in the field of scientific theory inevitably leads to application in the practical field of business to-morrow. The slow process of evolution of industry by improvements in mechanical equipment has given way to revolution of manufacturing processes by research. Within the last year or two many industries have felt the rising tide of competition, and not a few have slipped from their moorings. The very foundation of industries, unless they be anchored in the bedrock of pure science, threaten to be carried away. They carry on under the silent menace of the attack of competitors undermining the structure with the levers of applied science.

This year's reports of some of the most progressive manufacturing corporations devote a half page of text or less to the finances of the company. The balance of the report is concerned with the achievements in science, invention and new processes and products which have grown out of them. The spirit of these reports is typical of the far-sighted policies which guide many of our successful industrial corporations. There is no more significant characteristic of present-day corporation management than its efforts to peer into the future, and their attempts to forecast future trends.

Leading bankers also have begun to realize that it is not enough to know the commercial and financial condition of an industry; they must also know the technical assets which lie behind the balance sheet, because plant, process and product may fall "victims" to competitive research.

At this moment analysts are busy searching out

[1] An address before the American Association for the Advancement of Science, at Pasadena, California, June, 1931.

basic factors; statisticians present arrays of factual data as proof of their theories; and bankers keep daily tab on the shifting currents. They watch the surface ripples of industry and commerce for a sign as to which way the wind is blowing. Statistics, barometer charts, market letters, business cycles, carloadings as indicators of the state of industry and commerce are accessories after the fact. They are based on past performance. They are about as good as "racing form" in predicting the performance of any dark horse in the race for industrial supremacy.

Forecasting industrial futures, by a study of the present trend of research, will be reduced by trained observers to the same formulae and computations which govern the transactions in cotton and wheat futures on the New York Exchange. In the not far distant day of "the technical or science audit" of an industrial company, barometer charts based on technical, not the commercial, state of industry will appear. The technical audit, as a supplementary safeguard to the protective devices now used in long-term industrial loans, seems to be inevitable development in investment banking.

Some of the factors behind the scenes of the company balance sheet which play important rôles are the technical state of the art, the plant, the processes and the product. The attitude of the management toward research, available research facilities and technical advances in foreign countries, which may influence the domestic market, all have a meaning to the eye of a skilled observer. These may be translated into the language of dollars and cents—deficits or profits, dividends or assessments.

In this age of mass production, big volume, quick turnover, the average American business man wants action. A quick return. His conception of research is that it is something like a mysterious box of black magic, in which you should be able to put a research appropriation in the slot, turn the crank, and dollar dividends would roll out. Compare that picture with the vision and business judgment which financed the "speculations" of academic-minded Ph.D.'s, and were rewarded with the control of the dye markets of the world by Germany. It took fifteen years of research and an expenditure of 29,000,000 gold marks to produce the formula for aniline dyes, a good illustration of "patient money."

Men called dreamers, seekers after truth, pushing back the frontier of knowledge, making fundamental investigations of sound in the Bell Telephone Laboratories, are the first-line defense in safeguarding the capital investment of the largest single industrial enterprise in the world. Six thousand research workers are kept in the field as prospectors on the frontiers of industry at a cost of twenty million dollars a year. Years of toil on the borders of the unknown may be rewarded with a mere handful of nuggets—in the form of new facts. But the discoveries of these new facts has shaped the destiny of old industries and created new ones. Pure science investigations to increase the volume and to refine the quality of sound for long-distance telephony yielded unexpected dividends. The minted winnings of research produced much fine gold, while further reduction brought out by-products from the lesser ore. One of these, fashioned by applied science to the pattern of a specific need, laid the foundation for the talking movies, and put the silent pictures on the shelf!

In those early days the moving picture industry did not support a single research laboratory within its own ranks. The industry is still paying tribute for an "imported technology." Sperry, of gyroscope fame, developed a high intensity arc lamp which is actually "brighter than the sun" and brings California sunshine to Long Island studios "sets"—with the snap of an electric switch. Such is the power of this man-made light that the motion picture screen is brought close to the movie fan in the last row of the highest gallery of our largest cinema cathedrals. Colored movies came out of the laboratories of two Boston Tech professors, whose patient plodding in the physics and chemistry of light and color enabled them to "break into pictures." They find themselves a little bewildered perhaps, in the world of make-believe, these advocates of truth who practice in the court of nature, where there are no appeals, nor any exceptions granted. Their names have never "gone up in electric lights." The record of their achievement lies buried in laboratory notebooks, transitory guideposts on the path of progress. To-day there are more experimental laboratories on the movie lot than studios, and there are more technicians in Hollywood than actors.

The moving picture industry, working with a dynamic medium, is growing up, technically speaking. This industrial prodigy is one of the youngest in the large family of science-aided industries to emerge from the laboratory incubator, where the "children of science" are born.

It is almost axiomatic in the experience of the division of engineering and industrial research, N. R. C., that new industries, with processes in the state of flux, and with management unhampered by tradition and prejudice, are the most likely prospects for research. Radio and commercial air transport are also good illustrations of the lusty brood of the twentieth century generation of industries which have opened the door of opportunity with a science key!

Part of the broad policy of up-to-the-minute man-

agement of our industrial corporations is the eagerness with which far-sighted executives watch the developments of science. No advance in industrial technology is overlooked which may be turned to good account. With news reels bringing the latest "flash" reports from every corner of the science world, with popular science radio talks recording almost daily the triumphs of the test-tubes, in the battle for industrial supremacy, science is working in glass houses—that all may see. Industrialists not content with watchful waiting have become some of the most substantial contributors to the advance of pure science as well as to the technology of their own industries. Every year more and more laboratories are being set up, and the scope of their inquiries is steadily broadening. A National Research Council survey of 1920 lists 575 laboratories. By 1927 there had been a hundred per cent. increase, with over a thousand laboratories operating, as an integral part of the private industrial companies. To-day there are over 1,600 industrial laboratories. They serve as the far-flung outposts of American industry on the frontiers of knowledge.

To prophesy that any addition to the body of human knowledge will never be of any practical value is extremely hazardous. Who will say that Einstein's theory of relativity may not be the bedrock foundation on which a dozen industries as yet unborn may be erected in 1975? Who will be so rash as to predict the final result of the recent meeting of the world-renowned mathematical genius with Michelson and Millikan, both of them Nobel prize winners in physics? Hale, working in his "laboratory on the sun," brought down to earth helium, which has since been used in the building of fireproof dirigibles which have spanned continents and crossed the seven seas. Hardly two quarts of helium was known to exist on earth as late as 1914. Sometime ago this rare gas, discovered by dreamers gazing at the stars, was a cure for "bends," a temporary paralysis caused by working at great pressures which overcomes men burrowing in the earth and diving into the depths of the sea.

Science owes much to the modern tendency of the increasing use of science in industry and the debt is steadily increasing. The fruits of the applications of science provide the seeds with which to endow the planting of new gardens in which pure science may come to full flowers. Industry profits immeasurably by its vision in this direction. The testimony of the executive officers of a thousand representative industrial corporations, rated in the million-dollar class, is conclusive that research is a paying investment. Here a few typical statements are presented.

The president of a chemical manufacturing firm answers in no uncertain terms. "Research," he says, "is the one tool by which, within the short space of 12 to 15 years, American chemists, engineers and physicists have established in America an organic chemical industry, the magnitude of which is so great and the quality of whose product is so good that it is the marvel of our European competitors. In this field, the country to-day is practically self-supporting, as compared with the situation before the War when it was practically dependent upon European supplies."

In a different field of industry consider this statement made by the treasurer of a large textile plant, "We can figure that our leading profits are from 100 to 200 per cent. of the amount spent for research."

Another executive who has apparently determined his profits from research closely (he is vice-president of a rolling mill and steel concern) declared: "For every dollar spent in true research we have reduced costs and increased net revenue by at least $100." A particularly enthusiastic pulp and paper manufacturer has found his research laboratory "the biggest dividend-paying department."

The average annual premium paid by this representative cross-section of American industry is 1.3 per cent. of capital investment. Research appropriations are regarded by these executives as industrial insurance against competition. As an average for all industry, 31 per cent. of the investment in research is directed towards reducing production costs; 34 per cent. to improving the quality of products in service; and 20 per cent. to developing new fields of application; while the balance of 15 per cent. is used for developing new materials and products. The principal emphasis of research programs is on developments and improvements that will gradually improve production and increase dividends for the long pull. The public as a whole is the greatest gainer of all. The ultimate dividends of research are passed on to the consumer in reduced costs, improved quality and service and in dividends.

Industrial corporations, like industrial securities, may be divided in two major groups—preferred and common. Preferred securities attract the investor, primarily interested in the safety of his principal and a steady and assured income. Common stocks are conceded to be speculative. The public interest in investments in American industry is much larger than most of us realize. It has been estimated that there are fifteen million stockholders of industrial securities. No single investor in American Telephone in the legion of 550,000 stockholders in that company owns 1 per cent. of the stock. U. S. Steel, General Motors, General Electric and Standard Oil pay dividends to 600,000 or more "individual bankers" who have chosen to share their fortunes with these "indus-

trial giants." Recently an investment trust was organized in which investors were invited to share in futures of a representative group of industrial corporations, each of which is an acknowledged leader in its field. Every company in the group operates a research laboratory as an integral part of the company organization. The names of forty companies read like a blue book list of "Who's Who in Industry." The "and why" is summed up in the one word "research." The sponsors of this "trust" look upon research as an industrial security in this way: "Scientific research as it affects the industrial survival and competitive race of great companies, whose histories are measured by decades rather than by years, is a method—not a catchword, and in its place it is as important as methods of selling, production or accounting, although not quite so immediately effective." That statement would indicate that investment bankers and their customers, the investors in industrial securities, have begun to appreciate the meaning of "patient money."

Banking also takes a first-line position on the frontier of industry. The adventurous spirit of research opens up new territory, banking consolidates the position. The enterprise of research workers stakes out the claim; banking supplies the capital, to bring out the pay dirt. Research is a guarantee to the banker of invested capital, his insurance against loss in new enterprises. Research blazes a trail as the vanguard of industrial progress; banking builds a road to connect the frontier of industry with the main arteries of commerce.

OBITUARY

MEMORIALS

IT is reported in *Eugenical News* that at Neu Titschein, Czechoslovakia, near where Gregor Mendel was born, there was held on July 5 a celebration at the unveiling of a Gregor Mendel monument. The program was as follows: Professor Dr. Oswald Richter, of Brünn, gave an address on "Gregor Mendel and His Home," and Hofrat Professor Dr. Erich Tschermak-Seysenegg, of Wien, on "Mendel's Laws of Heredity and Their Significance for Plant Breeding." An address of welcome by Burgomaster Dr. Ernst Schollich, and an address by Professor Dr. Frimmel, of Brünn, was followed by the unveiling and a chorus. At 4 P. M. there was an "Ausflug" by auto to Mendel's birthplace in Heinzendorf.

THE review *Scientia* pays tribute to the memory of its late director, Dr. Eugenio Rignano, by founding a Eugenio Rignano Prize, of the value of 10,000 lire, to be conferred by international competition upon the author of the best essay on "The Evolution of the Notion of Time."

RECENT DEATHS

PROFESSOR EDWARD S. KING, professor emeritus of astronomy at Harvard University, died at his home in Cambridge on September 11 at the age of seventy years.

PROFESSOR RUSSELL LOVE MORRIS, professor of engineering at West Virginia University, died on September 1, at the age of sixty-two years.

MR. COURTENAY DE KALB, well-known mining engineer and former professor of mining engineering at the University of Missouri and the University of Alabama, died on September 2 at the age of sixty-nine years.

MR. EVERETT JOEL HALL, formerly professor at the School of Mines at Columbia University, died on September 3 at the age of fifty-four years.

DR. HENRY T. MCKINNEY, professor of education at Bethany College, died on August 30, following a minor operation. Dr. McKinney, who was treasurer of the West Virginia Academy of Science, was fifty-two years old.

SIR THOMAS STANTON, superintendent of the engineering department of the National Physical Laboratory, England, was drowned in Pevensey Bay, Sussex, England, on August 31.

DR. ARTHUR SIMARD, professor of surgery at Laval University, Canada, and past president of the College of Physicians of the Province of Quebec, died on September 3. He was sixty-three years of age.

PROFESSOR J. W. HINCHLEY, professor of chemical engineering in the Imperial College of Science and Technology and secretary of the Institution of Chemical Engineers, died on August 13 at the age of sixty years.

SCIENTIFIC EVENTS

THE AMERICAN CELEBRATION OF THE ANNIVERSARY OF THE INVENTIONS OF MICHAEL FARADAY AND JOSEPH HENRY

THE one hundredth anniversary of the discovery of electromagnetic induction will be observed by an elaborate display sponsored by the New York Museum of Science and Industry and the Radio-Electrical World's Fair. *The New York Herald Tribune* reports that the display, honoring the achievements of Michael Faraday, the English physicist, and Joseph

Henry, the American experimenter, will be presented at Madison Square Garden throughout the week of the Eighth Annual Radio-Electrical World's Fair, from September 21 to 26, inclusive. This observance will be one of the major American tributes to these men who are being honored in celebrations throughout the world during September.

Exact replicas of the Faraday and Henry inventions, complete in every detail and prepared after many months of work, will be shown to the public for the first time at the fair.

It was in the autumn of 1831 that Michael Faraday discovered that by moving a magnetized cylinder inside a copper wire coil an electric current flowed through the coil. Operating independently of Faraday, but at the same time, Joseph Henry, professor of engineering at Princeton University, was accredited with discovering exactly the same thing. A century has passed and the radio and electrical industries, born in the laboratories of Faraday and Henry, have grown to tremendous proportions.

On September 21 the centennial of Faraday's discoveries will be celebrated at the Royal Institution of Great Britain in London. Starting on the same date and continuing throughout the week America's tributes to Faraday and his American contemporary, Joseph Henry, will be made at the Radio-Electrical World's Fair.

The display will contain collections of Faraday and Henry objects. Many thousands of dollars have been spent in reproducing their inventions in exact replica. The Faraday group includes the Englishman's famous meter, magnet and ring. The Henry group includes the American inventor's electromagnet of 1829, the quantity magnet, electromagnetic motor, Morse recorder, galvanometer, commutator, armature, spiral, inductance coil and large electromagnet. Also in this group will be Sturgeon's electromagnet of 1826 in exact replica. Sturgeon is said to have caught the theory of electromagnetic induction earlier than Henry and Faraday, but his device was not widely accepted as proving the theory.

A second group of displays known as the electronics exhibit will also be shown at the Radio-Electrical World's Fair. The magic of electricity will be demonstrated in the museum's high-frequency demonstrations. Resonance is the subject of the fourth group of displays in the museum exhibit.

THE ANNUAL MEETING OF THE OPTICAL SOCIETY OF AMERICA

THE sixteenth annual meeting of the Optical Society of America will be held at Rochester, New York, from October 22 to 24. In addition to the usual program of papers contributed by members on their own initiative, the meeting will include the following:

(1) A session devoted to invited papers on Aerial Photographic Mapping. These will include: I. C. Gardner, "The Optical Requirements of Airplane Mapping"; Earl Church, "Analytical Methods in Aerial Photogrammetry"; C. H. Birdseye, "Photographic Mapping Instruments and Methods"; Edward H. Cahill, "The Brock Aerial Mapping Process"; H. L. Cooke, "Preparation of Relief Maps from Aeroplane Photographs"; Hamilton Rice, "Air Methods in the Exploration of Difficult Country—The Branco-Uraricuera-Parima River of Brazilian Guayana Expedition, 1924–25" (illustrated by motion pictures); Brazilian Guayana Expedition, 1924–25 (illustrated by motion pictures).

(2) A session devoted to invited papers on "Optical Problems in the Motion Picture Industry." The details will be announced in the final program.

(3) A complimentary dinner at the Bausch and Lomb plant, followed by an exhibit illustrating operations of the plant.

(4) Annual society dinner, followed by a trip to the University of Rochester to see the new buildings there.

(5) Presentation of the Frederic Ives Medal for 1931.

Sessions will be held at the Hotel Sagamore, the Auditorium of the new Research Laboratory of the Eastman Kodak Company, and the Physics Building at the University of Rochester.

A program of the meeting containing abstracts of contributed papers will be mailed to members about October 10.

The secretary was instructed by the executive council to place on all announcements of meetings that the society reserves the right of original publication of all contributed papers presented at its meetings.

The meeting will be open to non-members as well as members of the society. All interested persons are invited to attend. Non-members who desire to receive the advance program and final notices in regard to the meeting, hotel headquarters, etc., should address their requests not later than October 3, 1931 to L. B. Tuckerman, secretary, Optical Society of America, Bureau of Standards, Washington, D. C.

THE MUSEUM OF ANTHROPOLOGY OF THE UNIVERSITY OF CALIFORNIA

ARRANGEMENTS have been made for the removal of the University of California Museum of Anthropology from San Francisco to Berkeley.

It has been found necessary to move the museum from San Francisco because the old building in which it is housed must be torn down to make way for the University Hospital's outpatient department adjoining the hospital building at Second and Parnassus Avenues, which will be constructed at a cost of $500,-

000. It is believed that the museum will be more valuable as a teaching aid in Berkeley, where it will be convenient for the students. It is planned to house the collection in the old civil engineering building, which will be vacated with the completion of the new engineering group near Hearst Avenue.

The Museum of Anthropology, which is devoted to the history of man and his works, was founded by Mrs. Phoebe Apperson Hearst in 1901, and was opened to the public in 1911.

The chief collections in the building, which will have to be moved by truck across the San Francisco Bay, are: California Indian, 40,000 specimens; Egyptian, 21,000; North American Indian, 14,000; Central American, 3,500; African, 600; European, 1,385; Graeco-Roman, 5,000; Asiatic, 700; Philippine Islands, 1,000; Australia and the Pacific Islands, 2,200; Peruvian, 10,000; South American, 2,500, etc. There are in addition, 9,000 negatives of pictures, 2,416 phonograph records of Indian languages and music, 4,747 records concerned with physical measurements, 210 paintings, 3,575 lantern slides for lectures, and hundreds of maps, engravings and miscellaneous objects. The library consists of some 2,600 volumes. While the museum has always been cramped for space, much interesting material being stored away and never exhibited, the building now to be occupied is even smaller than the old one, and is not well adapted to museum needs.

THE ONE HUNDREDTH ANNIVERSARY OF THE LEEDS SCHOOL OF MEDICINE

No fewer than sixteen British and Irish universities, according to the London *Times*, were represented at the celebration at the University of Leeds on July 1, of the one hundredth anniversary of the founding of the Leeds School of Medicine, which is continued in the faculty of medicine in the present University of Leeds. Almost all the university delegates were men of national reputation, and the Royal Colleges of Medicine and Surgery in England, Scotland and Ireland, the great hospitals, medical schools in London, the General Medical Council, state departments, as the Ministry of Health and the Board of Education, the medical services of the Navy, Army and Air Force, and a variety of learned and professional institutions also honored the occasion by nominating special representatives who were men of the highest distinction in their respective fields.

The Duke of Devonshire, chancellor of the university, in welcoming the delegates from the universities and medical schools of Great Britain and Ireland and the representatives of the departments of state and of the societies, associations and learned institutions interested in medicine, said:

That the university had special pleasure in seeing present a representative of the Society of Apothecaries (the Master, Lieutenant-Colonel C. T. Samman) and of the Royal College of Surgeons (Mr. Fagge). To both of those institutions the Leeds School of Medicine owed much. To one of them, the College of Surgeons, the school had in part repaid its debt by providing it for the past four years with its president, Lord Moynihan, a former professor in the school and the first of its students to occupy the presidential chair of the college.

The predominant aim of the Leeds School had always been to turn out soundly trained professional men. In this he thought it might be that they had not been unsuccessful. The continuous and intimate association of the school with the Leeds Infirmary had been the prime source of its success, but it was to be noted that the governors of the infirmary had all along been a body quite independent of the school. Without their loyal and sympathetic cooperation the work of the school might have failed in its object. Since the school of medicine became the medical faculty of the university the medical departments had grown in extent and efficiency and the reputation of the school had steadily increased. Sir Algernon Firth and the late Lord Brotherton had enriched its resources by their generous benefactions, and those responsible for the school believed it was by no means at the end of its development.

The vice-chancellor, Sir James Baillie, claimed for the Leeds School of Medicine the merit of having utilized with success the labors of the founders of medical science, of having adapted their methods and experience to the needs of a new situation, and of making their own distinctive contribution to the expansion and advancement of medical knowledge.

Sir Humphry Rolleston, who was the representative of the University of Cambridge, replied on behalf of all the visiting delegates, tendering hearty congratulation to the Leeds Medical School on the attainment of its centenary and saying that the school had made itself famous, first in preventive medicine, then in clinical and curative medicine, and particularly in the evolution of abdominal surgery. The Leeds School had the distinction of initiating the study of the prevention of industrial disease and was the first to blaze the trail in this country.

Among the honorary degrees conferred were the following:

The degree of doctor of laws on Dr. Jane Walker, medical superintendent of the East Anglia Tuberculosis Sanatorium, Suffolk, a native of Dewsbury, and the first Yorkshirewoman to enter the medical profession; Dr. A. G. Barrs, emeritus professor of medicine at Leeds and for over fifty years connected with the school of medicine; Sir John Bland-Sutton, consulting surgeon at the Middlesex Hospital and noted in anatomy, pathology and surgery, human and animal; Lord Dawson, of Penn, president of the Royal

College of Physicians, and Sir George Newman, chief medical officer, ministry of health.

The degree of doctor of science was conferred on Walter Morley Fletcher, of the Medical Research Council, and Sir Frederick Gowland Hopkins, the physiologist and authority on biochemistry.

SCIENTIFIC NOTES AND NEWS

DR. WALTER S. ADAMS, director of the Mount Wilson Observatory, has been elected president of the American Astronomical Society. Dr. Willem de Sitter, professor of astronomy and director of the observatory at the University of Leyden, has been elected to honorary membership in the society.

DR. ROBERT A. MILLIKAN has been elected a senator of the national council of the United Chapters of Phi Beta Kappa.

THE Fukien Christian University, China, has established three scholarships in honor of Professor Maynard M. Metcalf, Professor C. G. Rogers and Professor R. A. Budington, "in recognition of their long years of famous pieces of research in biology and decades of teaching."

MR. MORRIS GOODKIND, of the New Jersey State Highway Department, has been awarded a medal by the American Society of Civil Engineers for the design of the bridge recently erected over the Raritan River near New Brunswick.

THE president and fellows of Trinity College, Oxford, have elected to an honorary fellowship Sir Henry A. Miers, from 1895 to 1908 Waynflete professor of mineralogy at Oxford.

PROFESSOR OTTO WARBURG, director of the Kaiser Wilhelm Institut in Dahlem, near Berlin, was awarded recently, by the faculty of medicine of Würzburg, the prize established by Dr. Josef Schneider, ophthalmologist of Milwaukee, together with a gold medal.

THE Chalmers Medal of the Royal Society of Tropical Medicine and Hygiene, founded in memory of the late Dr. Albert Chalmers, has been awarded to Dr. N. Hamilton Fairley for distinguished original work in tropical medicine, particularly in the field of serology of helminthic infections.

THE Adams Prize of the University of Cambridge, valued at about $1,000, which is awarded every two years for an essay on some branch of pure mathematics, astronomy or other branch of physical science, has been awarded to Mr. A. S. Besicovitch, fellow of Trinity College. The subject was "The Theory of Almost Periodic Functions."

THOMAS M. DUGAN, of McKeesport, Pennsylvania, secretary of the American Society of Sanitary Engineers, was made president at the annual meeting in Richmond, Virginia. He succeeds R. McGonegal, of Washington. J. F. Doud, of Cincinnati, was elected treasurer, and James R. Walker, of Waterbury, Conn., was reelected librarian.

PROFESSOR CHARLES SCOTT PORTER, associate professor of mathematics at Amherst College since 1929, has been appointed acting dean of the college. He has succeeded Professor Geoffroy Atkinson.

DR. ERNST GELLHORN has been promoted from associate professor to professor of physiology at the University of Oregon.

DR. NEIL E. STEVENS, of the Bureau of Plant Industry of the U. S. Department of Agriculture, has been appointed lecturer in the history of botany at the George Washington University.

DR. W. S. COLE has been appointed instructor in the department of geology at Ohio State University.

DR. C. H. GORDON, professor of geology and mineralogy at the University of Tennessee since 1907, having passed the age of 74 years, has been retired and given the title of emeritus professor of geology.

MR. O. T. KREUSSER, director of General Motors Proving Ground and of engineering tests of the Fisher Body Corporation, has been made director of the Museum of Science and Industry in Chicago.

DR. EDWIN A. ZIEGLER, senior forest economist in the U. S. Forest Service, has been appointed director of the Pennsylvania State Forest Research Institute.

DR. HENRY A. BARTON, assistant professor of physics at Cornell University, has been made executive secretary of the American Physics Institute.

DR. ALAN STONE has been appointed a member of the staff at the U. S. Bureau of Entomology as a specialist on mosquitoes and will take charge of the collection of these insects in the U. S. National Museum, succeeding the late Dr. Harrison G. Dyar. In the interval since Dr. Dyar's death, Mr. C. T. Greene has taken over the identification of mosquitoes in addition to his other work on Diptera.

DR. HENRI BRASSEUR, of Belgium, who has received his fourth consecutive fellowship, will work for three months at the California Institute of Technology with Dr. Linus C. Pauling, who was the first winner of the Langmuir Prize.

W. J. HEASMAN, of Trinity Hall, and G. J. Ker-

rich, of Christ's College, have been appointed, respectively, senior and junior curator of the museum of zoology, the University of Cambridge.

DR. FRANK SAMUELSON FELLOWS, past assistant surgeon of the U. S. Public Health Service, has been detailed to the Office of Indian Affairs as district medical director for Alaska to begin supervision for the first time of health work among the natives. He will leave Seattle on October 1 for Juneau, which will be his headquarters.

DR. CORNELIUS LANCZOS, of the University of Frankfurt, has been appointed visiting professor of mathematics and mathematical physics at Purdue University.

DR. JAMES EWING, professor of pathology at the Cornell University Medical College, has recently returned from Paris, where he attended the International Congress of Radiology.

DR. G. F. MCEWEN has been appointed chairman of the newly created committee on evaporation from free water surfaces of the American Geophysical Union. The committee will give particular attention to investigations of problems of evaporation from the surfaces of lakes, reservoirs, seas and other exposed bodies of water.

THE American Oil Chemists Society will hold the next meeting at the Congress Hotel, Chicago, Illinois, on October 29 and 30.

THE second international congress of Orientalists since the World War met at Amsterdam, Holland, on September 7. The first meeting was held at Oxford. Those in attendance included a number of Americans, Indians and Japanese, as well as many Europeans. A new feature of this congress was an autonomous section for the discussion of Greek papyrology, which was attended by those who participated in epigraphic and excavation work in Assyria, Palestine, Egypt, Persia and Asia Minor under the leadership of Professor James H. Breasted, director of the Oriental Institute of the University of Chicago. They include W. F. Edgerton, H. H. Nelson, G. Holscher, K. S. Sansord and P. L. O. Guy, all of the institute. The congress in general devoted itself to the study of all Oriental civilizations, but it was subdivided into several divergent groups, arranged geographically, for the study of China, Japan, India, Persia, Arabia, Asia Minor and Egypt, and chronologically for the study of Egyptology, Assyriology, Indology and Old Testament Islam. Among the most prominent Orientalists who took part in the discussions of the congress were Professor Littmann and Dr. Ernest Herzfeld, of Germany, Professor P. Pelliot and Professor L. Massignon, of France, Professor J. Capard, of Belgium, Professor C. A. Nallion, of Italy, Professor D. S. Margoliouth, of Oxford, and Professor J. J. L. Duyvendak and J. P. H. Vogel, of the University of Leyden. Professor C. Snouck Hurgronje, of the University of Leyden, who was responsible for the resumption of the sessions of the congress in 1928 after they had been interrupted by the World War, was the presiding officer.

THE twenty-fifth anniversary of the founding of the Vineland Laboratory of the Training School at Vineland, New Jersey, was celebrated from September 3 to 5. Professor Henry H. Goddard, professor of abnormal and clinical psychology at Ohio State University, was the guest of honor. Dr. Goddard was director of the laboratory at the school from the time of its founding in 1906 until 1918, when he left to take charge of the Ohio Bureau of Juvenile Research. On the evening of September 3, E. R. Johnstone, director of the school, gave an address on "The Institution as a Laboratory." On Friday morning the address by William J. Ellis, on "Research in Public Welfare," was followed by an address by Professor Arnold Gesell, professor of child hygiene and director of the psychological clinic at Yale University, on the "Study of Genetic Psychology." There was a reception in the evening. On September 5, the last day of the celebration, Dr. Edgar A. Doll, director of research at the school, gave an address on "The Outlook for Further Research." In the afternoon, Earl Barnes spoke on "Child Research and Social Progress." The address delivered by Dr. Goddard in the evening was followed by a smoker.

A CONFERENCE of the Association of Western State Engineers has been called for October 28, 29 and 30 in Sacramento, California. Subjects which are listed for discussion include "Federal and State Policies with respect to Control of Water," "Forethought in Planning the Development of Water Resources" and "Conservation and Administration of Public Domain." In addition to official state representatives from Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington and Wyoming it is expected that official representatives of the following federal departments will be in attendance: the Geological Survey, the Federal Power Commission, the U. S. Army, the Department of Agriculture, the Reclamation Bureau and the Forest Service.

THE committee on scientific research of the American Medical Association has made a grant of $500 to Vanderbilt University School of Medicine to aid in research on syphilis. These investigations are being

carried out under the direction of Dr. R. S. Cunningham.

AT the annual meeting in July of the trustees of the Beit fellowships for scientific research tenable at the Imperial College, South Kensington, which were founded and endowed in 1913 by the late Sir Otto Beit, Sir Campbell Stuart was appointed chairman of the trust, and Sir Alfred Beit a trustee, both in succession to the founder of the fellowships. New fellowships of the value of £250 a year, and tenable for two years, beginning in September, 1931, were awarded to Mr. William Henry Wheeler, formerly of the Luton Modern School, the University of Cambridge, and the Imperial College, for research on the effects of electric and magnetic fields upon gaseous explosions and detonations; and to Mr. Joseph Ivan Armstrong, formerly of the Royal Belfast Academical Institute, Queen's University, Belfast, and the Imperial College, for research on the respiration of fungi, with special regard to inorganic nutrition.

THE Medical Research Council of London announce that they have made the following awards of Dorothy Temple Cross fellowships for 1931–32, under the terms of the benefaction in that name for research fellowships in tuberculosis: Dr. Charles Allan Birch, senior medical registrar and tutor, Royal Infirmary, Liverpool; Roy Lars Vollum, demonstrator in pathology, University of Oxford. Dr. Birch has received a fellowship for the study of problems of tuberculosis at industrial centers in the United States. Dr. Vollum will study recent developments in methods for the investigation of tuberculosis in Germany and Austria. The fellowship awarded last year to Lieutenant Sidney Malcolm Burrows, late clinical assistant, tuberculosis department, St. Thomas's Hospital, has been renewed for a further year.

BETWEEN August 31 and September 3, 1931, an archeological conference was held at Vermillion, South Dakota, under the auspices of the University of South Dakota. Archeologists from Colorado, Iowa, Nebraska, Minnesota, Michigan, North Dakota, South Dakota, Wisconsin and the Smithsonian Institution were present, and each presented a brief review of the archeological situation in his area. Emphasis was placed upon problems and cooperation in the Upper Missouri River drainage and adjacent regions. The clear distinction between historic (documented), proto-historic (containing evidence of European contact), and prehistoric (strictly aboriginal) sites and cultures was strongly recommended in future work. Detailed discussion of field problems, aided by examination of sample collections of artifacts, brought about a keen appreciation of the interrelationship of the culture problems of this and adjacent regions. Through the courtesy of Dr. W. H. Over, certain members of the conference later visited a number of strategic sites in southeastern South Dakota.

DR. EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research in Pittsburgh, has announced that an industrial fellowship for research on moisture-proofing and grease-proofing paperboards used in cartons and boxes has been established in that institution by the Robert Gair Company, of New York City. Dr. Marion D. Coulter has been appointed a fellow of the institute, to conduct these scientific investigations. He is a specialist in organic chemistry, and from 1925 to 1930 he held a Mellon Institute fellowship for the study of certain problems in cellulose technology.

THE British Committee of Award of the Rhodes traveling fellowships announces that it has appointed Alfred Maurice Binnie, university demonstrator in engineering science at Oxford, Philip Aislabie Landon, fellow of Trinity College, and Nevill Henry Kendal Aylmer Coghill, fellow of Exeter College, to Rhodes traveling fellowships for 1932.

AFTER a two months' cruise in Alaskan waters on his yacht *Arminia*, General W. W. Atterbury, president of the Pennsylvania Railroad, who was accompanied by Mrs. Atterbury and two of their sons, has returned to Philadelphia with a collection of bird and mammal specimens for the Academy of Natural Sciences of Philadelphia. These include fur seals and sea lions, which the academy hopes to use in animal life groups to be erected in the North American Hall of its Free Natural History Museum, and a number of sea birds common to that part of the world which were secured as material suitable for a "bird rock" exhibit showing gulls, cormorants, auklets, puffins, terns and guillimots as in their native surroundings. The party sailed from Vancouver on June 30, and after visiting Kadiak and other islands, headed west for the Pribilof Islands in Bering Sea, the home of the great herds of fur seals. On the return journey to Sitka, Harry J. Lance, Jr., of the department of taxidermy at the academy, accompanied the party to assist in securing and preparing specimens.

WE learn from the *British Medical Journal* that the Sir Charles Hastings Clinical Prize, which consists of an illuminated certificate and a money award of fifty guineas, is again open for competition in respect of 1932. The following are the regulations governing the award: (1) The prize is established by the Council of the British Medical Association for the promotion of systematic observation, research and record in general practice; it includes a money award of the value of fifty guineas. (2) Any member of the association who is engaged in general practice is

eligible to compete for the prize. (3) The work submitted must include personal observations and experiences collected by the candidate in general practice, and a high order of excellence will be required. If no essay entered is of sufficient merit no award will be made. (4) Essays, or whatever form the candidate desires his work to take, must be sent to the British Medical Association House, Tavistock Square, London, W.C.1, not later than December 31st, 1931, and the prize will be awarded at the annual general meeting of the association to be held in London in July, 1932. (5) No study or essay that has been published in the medical press or elsewhere will be considered eligible for the prize, and a contribution offered in one year can not be accepted in any subsequent year unless it includes evidence of further work. (6) If any question arises in reference to the eligibility of the candidate, or the admissibility of his or her essay, the decision of the council on any such point shall be final. (7) Each essay must be typewritten or printed, must be distinguished by a motto, and must be accompanied by a sealed envelope marked with the same motto, and enclosing the candidate's name and address. (8) The writer of the essay to whom the prize is awarded may, on the initiative of the science committee, be requested to prepare a paper on the subject for publication in the *British Medical Journal* or for presentation to the appropriate section of the annual meeting of the association. (9) Inquiries relative to the prize should be addressed to the medical secretary.

FORTY-SIX species of birds that inhabit the Himalayas have been received by the Roerich Museum, New York City, in the first group of ornithological collections to be sent from Urusvati, Himalayan Research Institute of the Roerich Museum, at Naggar, Kulu, Western Himalayas. The species include the griffon, giant mountain bird of prey, the sacred crane of India, the lammergeyer or bearded vulture, the horned owl, the moorhen, hoopoo, sun birds, orioles, rose-fringed parrots, the long-tailed paradise fly-catcher and the monal, whose feathers shade from copper green and purple into a light brown tail. The birds were obtained by the two biological expeditions sent out under Dr. Walter Koele. The first went through the Kulu Valley and Lahul, across the Rothang Pass. The second went into Rampur Bashahr through the Sutlej Valley. An ethnographic-archeological-linguistic expedition is also being conducted in Lahul by Dr. George Roerich.

DISCUSSION

THE CONTROL OF PREDATORY MAMMALS

THE United States Bureau of Biological Survey, in the attempt to control predatory mammals and obnoxious rodents, has adopted policies which have caused the naturalists and conservationists at large grave concern for some years. As far back as 1924, the American Society of Mammalogists, at the annual meeting held in Cambridge, April 15–17, protested against the survey policy of extensive campaigns of predator destruction, and at subsequent annual meetings the mammalogists have maintained a practically unanimous stand against the field practices of the survey as far as they relate to drastic control measures.

Far from heeding what has been tantamount to a nation-wide protest, the survey has steadily built up such an extensive and powerful control machine that to-day our western wild life is confronted with the most serious crisis in its history. Realizing that the time for passive criticism had passed, the Society of Mammalogists, at the New York annual meeting of May, 1930, appointed a special committee on the problems of predatory mammal control, instructing this committee to attempt a critical investigation of actual conditions in the field, in which the committee personnel would cooperate as far as possible with special investigators from the survey.

The committee was able to conduct joint and independent investigations during 1930–31, which involved an itinerary of more than 12,000 miles in the Western United States. Although the region to be covered is so vast, and the conditions so complex, that these studies can be considered as only a start upon the research which should be made into the life-histories of our western mammals and their relations to habitat, to vested interests and to the public in general, nevertheless enough was accomplished to confirm the society in its belief that undue value was being placed upon the claims of destruction done by mammals and that the control policies of the survey were placing an excessive toll upon all wild life in the attempt to control a few species.

The committee presented its report at the annual meeting held in Philadelphia on May 14, 1931. After discussion, the report was adopted by the membership with only two dissenting votes. It is no secret that some of the naturalists in the survey employ are much concerned over a policy with which they are not in accord and which has been continued and developed in response to powerful lobbies backed by special interests. From a small beginning, the control activities of the survey have been rapidly increased until they have assumed a dominating influence upon the conduct of the survey. It is not difficult to understand how research and study into faunal relationship have been relegated to a post of minor importance,

as the swelling appropriations for the slaughter of predators and rodents have demonstrated the success of this latter activity as a means of securing support from a Congress, ready to listen to any tale touching upon the interests of the live stock owner or agriculturist.

As an instance of this doubt upon the part of some of the survey personnel that the policy of the survey toward predators should be defended, the remarks and conclusions of one of the survey's own investigators was read at the annual meeting. The chief of the biological survey had shown his fair-mindedness in the joint investigations by exchanging field reports with the special committee of the mammalogists. These remarks drew attention to the propaganda disseminated through survey channels and which was designed to paint certain species of mammals in the blackest tones and to create a desire for destruction wherever the public was lukewarm to these practices of the survey.

During the discussion a member from Canada pointed out that a political boundary should not change the biological principles involved in this problem and remarks by others showed that no such tax upon wild life was either exacted by Canada or deemed necessary to protect her farmers and drovers.

After summarizing the conclusions and opinions of the committee as based upon extensive data, the committee recommended to the society the following resolutions, which were passed, as stated above.

(1) That the society strongly urges the Biological Survey that the use of poison as a control measure against predatory mammals be drastically curtailed, with the view of complete suspension of poisoning as soon as it is reasonably possible.

(2) That the society deplores the propaganda of the survey which is designed to unduly blacken the character of certain species of predatory mammals, giving only part of the facts and withholding the rest, and which propaganda is educating the public to advocate destruction of wild life.

(3) That the society asserts the claim of the great nature-loving public to a voice in the administration of our wild life resources, and challenges the right of a federal organization, such as the Biological Survey, to consider only the interests of a very small minority, the live stock interests.

It will be noted that the special committee has concerned itself chiefly with the problems raised by predatory mammal control. While these questions have been of paramount importance in the past, the employment of more deadly poisons against rodents, with a consequent more ruthless threat against all the animal life of the region where these operations are in force, has thrust forward the entire subject of the control policies of the survey as a topic of vital importance to every true conservationist.

Dr. Jean M. Linsdale, in the *Condor* of May, 1931, has written an account of the use of thallium as a poison against the ground squirrel in California. This is a calm statement of findings and must impress the reader as an investigation conducted without bias or prejudice. Dr. Joseph Grinnell, in the same publication, in commenting upon Linsdale's data, figures that in four years, in California alone, not less than 50,000,000 animals other than ground squirrels have been killed through these operations. This extermination has been carried on either under the direction or with the cooperation of the Bureau of Biological Survey and, during these years of thallium poisoning, spokesmen of the survey have been assuring the Society of Mammalogists that the taking of wild life was a regrettable duty and that, as far as it was humanely possible, every protection was being given to non-injurious species. The exposé by Linsdale shows how far the survey had been curtailing control activities at the time these pronouncements were made. As a fitting climax to the drama of thallium, the United States Department of Agriculture, in Bulletin No. 238, April, 1931, written by Munch and Silver (the latter in the survey), discusses the use of thallium in rodent control and concludes with these significant words:

> Thallium is a cumulative poison of high toxicity and is without taste, smell or other warning property. It should not be recommended to the public as a rodent poison. Where the use of thallium is found necessary for the control of highly resistant species of rodents, it should be entrusted only to persons who understand its dangerous qualities and who will exercise appropriate care in handling it.

When 602,728 pounds of grain poisoned by thallium are scattered in California in one year, 1929 (*vide* Linsdale), one wonders what constitutes "appropriate care."

Dr. Witmer Stone, in an editorial in the *Auk*, July, 1931, page 477, expresses the attitude of all of the ornithologists who are informed on the matter, when he stresses the danger to bird life from such campaigns as the thallium drive of California. He concludes: "If ever the 'appeal of the bird itself' needs our support it does so now."

The list of societies and opinions cited above might be greatly extended and organization after organization has gone on record as opposed to the present control policies of the Biological Survey. This criticism is not the utterance of a few fanatics, as some of the survey champions would have one believe, but rather it is the most universal formal statement of

opinion which has ever been expressed upon any activity of the survey.

The repercussions of the control policies of the survey are many and varied. The mouse plague of Kern County, California, 1926–7, has been attributed, with reason, to the poisoning of predatory mammals, a natural control over the numbers of mice. The fur trade is concerned over the fur-bearers needlessly killed by survey poison squads. A strong argument against extermination or near-extermination campaigns can be advanced on esthetic grounds for surely a young, faunally rich country like the United States does not wish the great open spaces swept clear of all wild life in order to make the West a sheep man's paradise. The American public should love its wild life and want it preserved in its original entirety as far as is reasonably possible.

But unless nature lovers throughout the length and breadth of the country assert themselves and demand a pause in this organized slaughter, the Biological Survey will continue to develop the technique of destruction and to expand along the lines which have proved to be such a bureaucratic success. The survey is subjected to great pressure by the forces working for specialized control; it is placed in an exceedingly awkward position. The conservationists must exert an even greater pressure against the control policies of the survey in order to accomplish any useful end. For awkward as is the plight of the survey, the lot of our wild life is even more precarious.

H. E. ANTHONY

AMERICAN MUSEUM OF NATURAL HISTORY

FITTING THE CURVE OF THE DIMINISHING INCREMENT TO FEED CONSUMPTION-LIVE WEIGHT GROWTH CURVES

IN a recent paper,[1] Hendricks, Jull and Titus suggested a method of interpreting the results of feeding experiments by means of the curve of the diminishing increment. The senior author felt that the method might be more useful to workers in animal nutrition if the curve of the diminishing increment could be accurately fitted by some rapid method.

The most rapid method of determining the constants in the equation:

$$W = A - Be^{-kF} \qquad (1)$$

proposed up to the present time, is, perhaps, the method of arithlog plotting used by Brody.[2] However, it has been the experience of investigators at the U. S. Animal Husbandry Experiment Farm, Beltsville, Md., that, in many instances, it is difficult to judge accurately which value of the constant, A, makes the values of log $(A - W)$ lie most nearly along a straight line, when plotted against the corresponding values of F as abscissae.

The writer has tried a method of approximating the values of the constants which appears to give much more accurate results than the method of arithlog plotting.

The differential form of equation (1) may be written:

$$\frac{dW}{dF} = C - mW \qquad (2)$$

in which, $C = kA$, and, $m = k$. If finite increments are substituted for the infinitesimals of the Calculus, equation (2) becomes:

$$\frac{\Delta W}{\Delta F} = C - mW \qquad (3)$$

in which the ratio, $\frac{\Delta W}{\Delta F}$, represents the gain in live weight, per unit feed eaten, over a short interval of time, and W represents the average live weight of the animal during that interval of time, calculated by taking one half of the sum of the live weights at the beginning and at the end of the interval.

The values of the ratio, $\frac{\Delta W}{\Delta F}$, for consecutive intervals of time, lie along a straight line, when plotted against the corresponding values of W as abscissae. A simple linear equation of the form, $Y = aX + b$, may be easily fitted to such a set of data by the method of least squares.

It is readily apparent that the slope of the fitted straight line is $-m$. The intercept of the line on the axis of ordinates is C, since when $W = 0$, $\frac{\Delta W}{\Delta F} = C$. The intercept of the line on the axis of abscissae gives the mature weight of the animal, since when $\frac{\Delta W}{\Delta F} = 0$, $mW = C$, and $W = \frac{C}{m}$, or A. The value of the constant, B, in equation (1) may be calculated by subtracting the initial weight of the animal from the mature weight, A.

The writer fitted equation (3) to data obtained from two lots of chickens which had been weighed each week up to the age of one year. The values of C, which Hendricks, Jull and Titus (*loc. cit.*) have interpreted to represent the true efficiency of the feed for growth, were found to be 0.343 and 0.355, respectively. The corresponding values, calculated after carefully "adjusting" the constants of the integrated

[1] Walter A. Hendricks, Morley A. Jull and Harry W. Titus, "A Possible Physiological Interpretation of the Law of the Diminishing Increment," SCIENCE, 73: 427–429, 1931.

[2] Samuel Brody, "Growth and Development with Special Reference to Domestic Animals. III. Growth Rates, Their Evaluation and Significance," *Mo. Agr. Expt. Sta. Bull.* 97, 1927.

equations by the method of least squares, are, respectively, 0.340 and 0.356. The error, due to the use of the rapid method of fitting the curves, was less than one per cent. in each case, which is undoubtedly well within the limits of the experimental error involved.

The chief source of inaccuracy in the rapid method of fitting the curves probably lies in using the gains in live weight, per unit feed eaten, over finite intervals of time as approximations to the values of the derivative, $\frac{dW}{dF}$. If the chickens used in the writer's study had been weighed at less frequent intervals, the rapid method probably would not have yielded quite such accurate results.

The advantages of this method over the method of arithlog plotting are the elimination of the errors of judgment, which are inherent in the latter, and the fact that the value of the constant, C, which is of particular interest if the curve is used to interpret the results of a feeding experiment, can be determined directly.

WALTER A. HENDRICKS
BUREAU OF ANIMAL INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE

THE EFFECT OF THE APPLICATION OF A FIELD OF ATTRACTION TO A GAS

CONSIDER a gas of molecules, or electrons, in a shallow vessel having two of its plane walls parallel to each other. The vessel is placed in a field of attraction with these walls at right angles to it. Let us suppose that the conditions are such that a molecule on moving from one of these plane walls to the other has little chance of undergoing a collision with another molecule. Hence when a molecule moves from one of the plane walls to the other against the field, it undergoes a decrease in velocity, while when it moves in the opposite direction its velocity undergoes an increase. Hence the molecules impinge and rebound from one of the walls with a greater velocity than is the case at the other wall. Now the velocity of rebound[1] is an index of the temperature of the gas close to the wall; and hence under these conditions there will be a continual transference of heat from one wall to the other. But this is thermodynamically impossible. It follows therefore that the molecules must undergo certain changes compensating for this effect of the field. The occurrence of inelastic collisions of the molecules with the walls can not, it will be found, by themselves explain the effect. If, however, we suppose that the molecules possess certain properties previously deduced in other ways,[2] this effect can be compensated for. These properties are: (a) A molecule, or electric charge, slows down when moving freely, and absorbs radiant energy in the process which is stored up as internal energy; (b) potential energy of attraction, or repulsion, may become internal energy, and *vice versa;* (c) internal energy may also be directly converted into radiation.

We may now suppose that the internal energy accumulated by a molecule during its motion according to (a) and (b), is mainly converted into potential energy of repulsion according to (b), and this into kinetic energy, at the wall where the molecules arrive with a decrease in velocity. This is to take place in such a manner that the average velocity of collision is reduced at one of the walls and increased at the other, so that the temperature is the same at both walls.

If a different explanation of the difficulty is possible, I shall be glad to hear about it.

R. D. KLEEMAN
SCHENECTADY, N. Y.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE IOWA EYE-MOVEMENT CAMERA

MANY efficient cameras for photographing eye movements have been built since the inauguration of the corneal reflection method of eye photography by Dodge in 1901. The first cameras obtaining a continuous record of eye movement recorded only the horizontal movements of one eye. Dearborn made an advance by recording the vertical movements of one eye on a horizontally moving film and the horizontal movements of the other eye on a vertically moving film. The camera herein described obtains simultaneous binocular records of both vertical and horizontal movements.

The light used to produce the corneal reflection for photographing is a direct current Bausch and Lomb automatic carbon arc. This light, screened from the view of the reader, is placed at right angles to the eyes as is illustrated in Fig. 1. The light is focussed by a large condensing lens on a diaphragm which allows only the center of the light from the positive carbon to pass on. Between the light and the diaphragm is a chopping disc operated by a synchronous motor which interrupts the beam of light fifty times

[1] Apart from the increase caused by the attraction of the wall. R. D. Kleeman, *A Kinetic Theory of Gases and Liquids*, John Wiley & Sons, New York.

[2] R. D. Kleeman, *Phil. Mag.*, 7: 493, 1929; *Nature*, 124: 728, 1929; SCIENCE, 70: 478, 1929; 71: 340, 1930; 72: 224, 1930; *Z. anarg. u algem. Chemie*, 196: 284, 1931; *Z. Electro-chemie*, 37: 77, 1931; 37: 371, 1931.

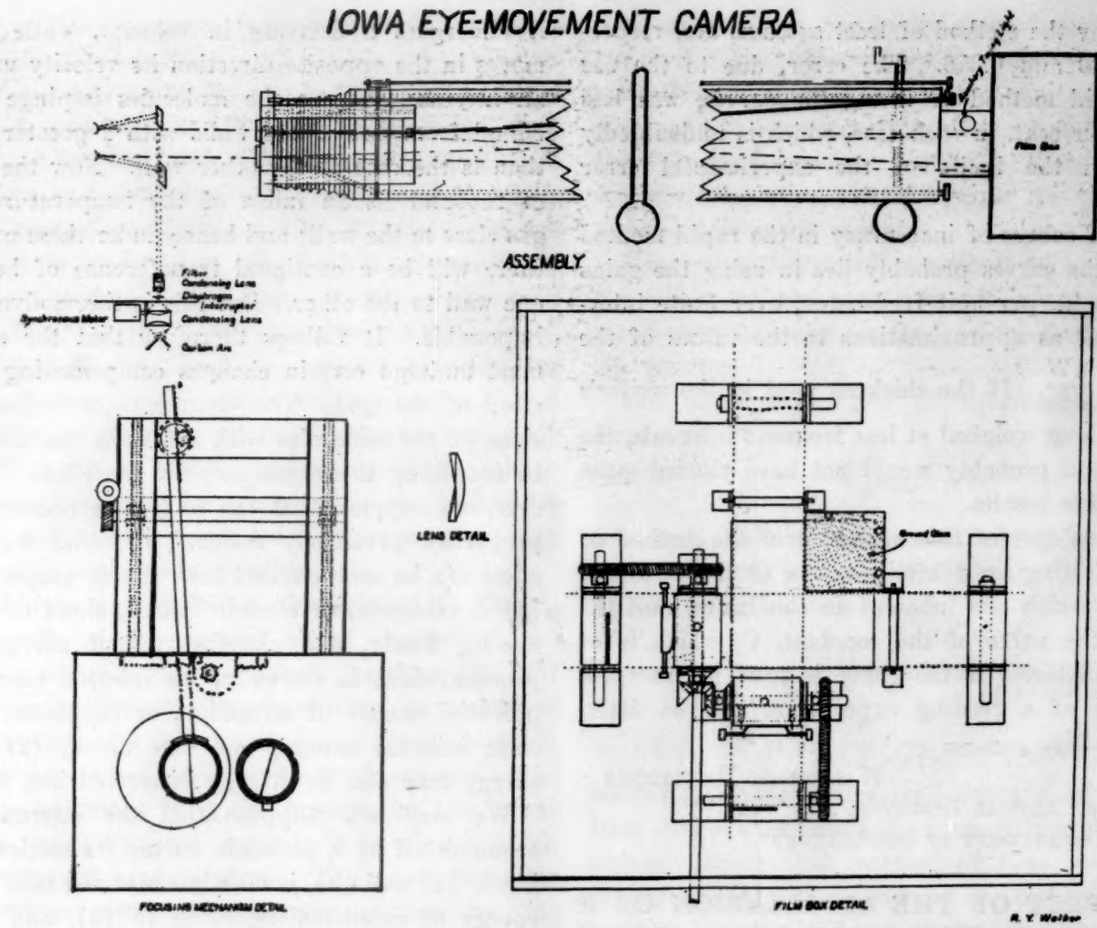

FIG. 1.

a second. The rays of light passing through the diaphragm are converged to a pencil beam by a second lens. The beam then passes through three cobalt blue filters before being reflected from two adjustable first surface mirrors to the eyes.

Since this camera requires that the light reflected from each eye be recorded on two papers it was necessary to introduce a system of dividing the light beam from each cornea into two beams. With the aid of the local branch of the Riggs Optical Co. a pair of prisms were ground and mounted with Canada balsam base out on the plano surfaces of 2.5 diopter, 35 mm diameter crown glass lenses. The prism strength of the left lens was 1.25 degrees, the right lens 1.5 degrees. The difference in strength is necessary to permit the proper aligning of the reflected beams on the recording paper.

The entire lens unit is mounted so that it may be adjusted in three dimensions. Vertical and depth adjustments are made by racks and pinions on the lens mounting. Horizontal adjustments are made by a worm at the rear which pivots the entire camera box. The lens for the left eye is adjustable independently in the horizontal and vertical by means of racks and pinions as illustrated in the focussing mechanism detail (Fig. 1). All lens adjustments are made from the rear by means of telescoping rods.

The lenses, mounted approximately 20 cm from the eyes, focus the reflections from the corneas at the end of the camera box which is about 180 cm from the lens mounting. This amplifies the movement nine times and permits the use of weak prisms, thereby insuring a sharp focus.

Eastman No. 1 recording paper, 1¾ inches wide, is moved synchronously in the vertical and horizontal directions by the mechanism illustrated in the film box detail (Fig. 1). Spiked traction rollers insure positive movement of the paper between the guide rollers to the windup rollers. A constant speed motor with a variable reduction gear is used for driving power. A satisfactory rate of speed for most records is from 7 to 9 cm per second. Good records may be obtained at speeds up to 20 cm per second.

To facilitate focussing a piece of ground glass was mounted in one quarter of the aperture of the film box. When a correct focus is obtained a slight shift of the camera in the horizontal and vertical places the beams of light in their proper place on the recording paper.

A mercury filled neon glow lamp is used as an auxiliary timing light or signal marker. The light, located in the rear of the camera, as indicated in the assembly (Fig. 1), passes through a slit dia-

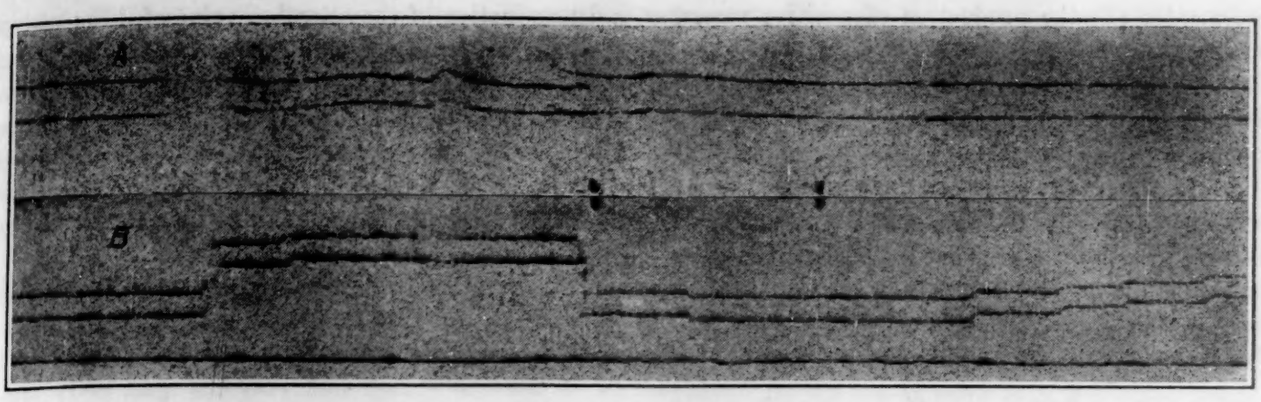

FIG. 2. Record A is the horizontal moving film which records the vertical movements of both eyes. The two upper lines in record B record the horizontal movements and the base line records the head movements on the vertical moving film. The strips of recording paper in this record are reduced from 1⅞ inches.

phragm and a condensing lens and is reflected from a mirror on the base of the inner side of the box to a focus across the intersection of the two recording papers. A perfect matching of the two records is thus made possible by matching the lines made on both records by a single light. This light may be flashed at regular intervals as an auxiliary timing device during reading movements, or it may be used to indicate the exact time of appearance of various other types of visual stimuli, or to indicate any other phenomena to be especially noted on the record.

The sample record in Fig. 2 shows the vertical and horizontal movements of the eyes in horizontal fixation movements and in the beginning of the reading of printed material. The first horizontal movement (reading from left to right) in record B is that of the eyes moving from left to right between the two fixation points placed above the first and last letter of the first line of the printed material. .78 mm movement on the record represents 1 degree of angular eye movement. The movement is indicated in record A by the spreading of spots due to the beams of light moving in the opposite direction to that of the recording paper. The next curve in record A indicates a marked upward twitch of the eyes of .1 second duration. The next movement indicated in both records is the return sweep from right to left preparatory to the beginning of reading. Since this movement is made in the same direction and faster than the movement of the recording paper it is indicated on record A by an overlapping of the lines of spots. The succeeding part of the record is that of a long fixation at the beginning of the line and the saccadic movements and fixation pauses during reading.

The base line of head movements in record B is obtained by recording the reflection from a steel ball mounted on a spectacle frame worn by the reader. The two adjacent marks on both records are produced by the signal marker mentioned above.

There are two methods of obtaining time measurements on this record: (1) The duration of any single movement may be measured by counting the number of small spots contained in that movement, each spot being equal to .02 second. These small spots are produced by the interruption of the light beam by the chopping disc described above. (2) Gross measurements may be made by measuring the length of record made by any movement and converting them into time measurements according to the speed of the recording paper. The exact speed of the paper may be continually checked by measuring the distance between the dashes in the record which occur twice a second. These dashes are produced by removing two of the interrupters in the chopping disc. This disc carries 25 interrupters (23 with the 2 omitted) and revolves twice a second, hence the dashes appear twice a second and are .05 second long.

In studying binocular coordination it is necessary to know the position on the record of one eye relative to the other. The dashes in the record, since they are produced by an interruption of the light previous to any division of the beam, make the relative position of the two eyes clear throughout the record.

The large cost of many of the satisfactory eye-movement cameras now in operation has heretofore prohibited their use in several laboratories. The cost of the materials used in the construction of this camera amounted to less than one hundred and fifty dollars. The use of recording paper costing about one cent a foot is an additional saving in expense as well as an aid in reading. The entire mechanism was built in a good laboratory shop by graduate students who were not skilled mechanics.

In summary the advantages of the Iowa Eye-Movement camera may be stated as follows: (1) Simultaneous recording of binocular horizontal and vertical

movements; (2) the production of positive record of sufficient magnification for easy reading; (3) readily adaptable to various types of eye-movement problems other than reading; (4) low cost of construction and operation.

The problems for which this camera is now being used are: (1) The study of binocular coordination in convergence and divergence movements of alternate fixation on near and far points of light; (2) the analysis of eye movements of good and poor readers who have the same intelligence rating; (3) the determination of the attention value of different types of advertisements and of different items in a single advertisement; (4) analysis of changes that take place in eye-movement habits of poor readers who have been subjected to intensive remedial training; (5) binocular coordination of stutterers *versus* that of normal speakers, and (6) dysintegration of eye-movements during stuttering spasms.

HERBERT H. JASPER
ROBERT Y. WALKER

UNIVERSITY OF IOWA

SPECIAL ARTICLES

THE GREAT GLACIAL CYCLE

IT is fairly well known that the present Ice Age, or the cycle of ice ages in an interglacial period of which we now live, was preceded by other ages or cycles of ages, leading as far back as we can see in geological history.[1] Some of these have been limited in extent, both of time and area, but others have involved large areas of the earth for millions of years. If we consider the greater cycles that are most recent and most certainly identified, and compare them with the absolute dates which have been obtained from radioactive changes,[2] we find that they occurred at intervals of some 200,000,000 years. Thus we may make the following comparisons, giving the periods in millions of years. I have used a unit of 210 millions, as it seems to fit a little better than the even 200, especially at the Cobalt glaciation, but the uncertainty of the data makes the difference trivial.

210. *Permocarboniferous Glaciation*

204. Joachimstal pitchblende, supposed Permocarboniferous.

239. North Carolina uraninite, supposed late Carboniferous.

A very long and widely distributed glacial period, mainly in the southern hemisphere and lasting through the later Carboniferous and much of the Permian, with its climax at the beginning of the Permian.

420. *Late Ordovician Glaciation*

374. Branchville, Ct., uraninite; Silurian or Devonian.

443. Lake Superior coracite; early or middle Ordovician.

This cycle is not so well defined, but seems to cover larger area in Quebec, and is also represented in Europe.

630. *Early Cambrian or late Precambrian Glaciation*

573. Katanga pitchblende; late Precambrian.

587. Ceylon thorianite; late Precambrian.

673. Morogoro, Tanganyika; late Precambrian.

This shows a very large area of glaciation in the world, but much of it is of uncertain date and may belong to the following period; back from this time fossil dating is no longer possible, and it becomes difficult to join up dated igneous rocks with the corresponding glacial deposits, except where, as at Cobalt, they are directly associated.

840. *Keweenawan*

No dated radioactive rocks; Reeds gives this as the date for the Keweenawan, which shows doubtful glacial remains about Lake Superior.

1050. *Cobalt (Huronian)*

987. Olary, S. Australia; Animikian.

1024. Ontario uraninite; Animikian.

1056. Arendal, Norway, cleveite; Cobaltian.

1087. Llano Co., Texas, uraninite and Douglas Co., Col. Samarskite; Cobaltian.

This is evidently a major glaciation at least in Canada, where the Cobaltian radioactive dated rocks and glacial remains are directly associated. Coleman discusses the Animikian as Precambrian and the Cobaltian as Huronian, but the radioactive dating suggests a single cycle. Extensive glacial traces elsewhere may belong to this cycle.

1260. *Algoman*

No dated glacial remains.

1470. *Timiskamian*

1465. Keystone, South Dakota, uraninite, Timiskaming.

Extensive glacial traces in Canada, doubtful elsewhere.

1680. *Keewatin*

Doré conglomerate of Canada a possible representative of this or an earlier cycle. No radioactive dating, so far as I know.

Plaskett[3] has just estimated that it takes the solar system 230,000,000 years to make the great circle around the system of the Milky Way. The rough agreement suggests a connection. It is well known that at present the dense center of the Milky Way

[1] A. P. Coleman, "Ice Ages, Recent and Ancient," New York, Macmillan, 1926.

[2] Holmes and Lawson: *Am. Jour. Sci.* (5) 13: 327, 1927, brought up to date and diagrammatically presented by C. A. Reeds, *Nat. Hist.* 31: 129, 1931.

[3] *Proc.* Am. Phil. Soc., 69: 417, 1931.

is obscured behind a cloud of opaque matter. It may be suggested that this center radiates a small but substantial amount of heat, sufficient to raise the temperature of the earth a few degrees. If this is the case, during the periods when the earth does not lie behind the obscuring cloud, it will be a few degrees warmer, and when the cloud passes in front, the temperature will drop a corresponding small amount. Such a small difference in temperature may well make the difference between a stretch of time when glacial periods are frequent and wide-spread, and one when they are rare and mainly limited to mountain areas.

As the obscuring cloud is nearer to the center of the Milky Way than ourselves, the obvious assumption is that it is revolving about the center more rapidly than ourselves (obviously in the same direction). We can calculate what its period would have to be, to occult the center every 210 million years, and it works out at 110 million years. Assuming that most of the mass of the Milky Way is concentrated at its center (Plaskett suggests 80 per cent.), this would make the radius of its orbit of the order of 5,000 light-years.

If this is the case we have gone about the center of the Milky Way some eight times, and the obscuring mass about 17 times, since the oldest visible rocks were laid down, some 1,850 million years ago.

This scheme is presented as a suggestive hypothesis, rather than a full-fledged theory. Its chief weaknesses are two: one due to the uncertain dating of the geological deposits, especially as glacial deposits and datable radioactive ones (igneous) are rarely found in close association; the other, which Dr. Boothroyd would emphasize, that the amount of radiation possible from the center of the galaxy would not be able to raise the temperature of the solar system even the few degrees necessary. A systematic error in the radioactive datings might change the figures involved somewhat, but could hardly be large enough to interfere seriously.

WM. T. M. FORBES

CORNELL UNIVERSITY

EGGS OF FRESH-WATER FISHES SUITABLE FOR PHYSIOLOGICAL RESEARCH[1]

Fundulus heteroclitus, a marine Poeciliidae commonly called the killifish, or marine minnow, has been used for many years as the standard fish for various types of physiological research. Their eggs are especially well adapted for experimental studies due to the fact that they can be easily fertilized in the laboratory and their embryos can be observed during development through the transparent shell membrane.

It is not always possible or desirable, however, for the investigator to conduct his research at a marine biological station but since several of the fresh-water laboratories are now equipped for fundamental physiological research as well as for ecology, life-history and taxonomic studies, it may be of interest to call attention to a few species of fresh-water fishes, the eggs of which have been found to be very satisfactory for research on the beat of the embryonic heart. By the use of these eggs it is often possible for the inland investigator to conduct his research in or near his own laboratory.

The log-perch (*Percina caprodes*)[2] is one of the larger and more abundant of the darters belonging to the family Percidae. It occurs in all the Great Lakes, in Lake Champlain, in the St. Lawrence and the various tributaries of this system and ranges south to Virginia, Alabama and throughout the Ohio basin, westward to Kansas, and southwestward to Texas. An excellent colored plate and description of this species is contained in Forbes and Richardson's "Fishes of Illinois." The plate is opposite page 282.

The adults are found in schools of several hundred at spawning time. The spawning beds are found along the shallow windswept shores of lakes, usually where sand is abundant. When the water is quiet the schools move to the very edge of the lake and spawn in a few inches of water. Spawning takes place during the day time on quiet days. The males remain in a group while the females rest on the sand at the edge of the spawning area. At intervals the individual females move toward the group of males, one of which starts spawning with her, during the progress of which the eggs and sperm are emitted while the tails vibrate in such a way as to dig a pit in the sand and cover many of the eggs. Reighard[3] has described the spawning and method of sex recognition of this species in excellent detail. Spawning takes place from as early as June 15th and may continue as late as July 20th at the University of Michigan Biological Station on Douglas Lake in Northern Michigan.

During the spawning season log-perch are easily collected with a twenty-five or thirty foot minnow net. The fish can be stripped immediately and the eggs fertilized in finger bowls or syracuse watch-glasses or fishes may be kept in an aquarium with the water at a cool temperature and stripped when desired. A 70 to 80 per cent. fertilization is usually secured if the eggs are fertilized by the dry method. The eggs are collected in the dry watch-glasses and

[1] Contributions from the University of Michigan Biological Station, North Dakota State College, and The College of the City of Detroit.

[2] For a discussion of the taxonomy of this species see Hubbs and Brown, *Trans.* Roy. Can. Inst., 17: 1–56, 1929.

[3] Reighard, Papers of Mich. Acad. Sci., p. 104–105, 1913.

the concentrated sperm poured over the eggs and a minute or two allowed to elapse before the addition of water. The watch-glasses are then kept in a covered crystallization dish filled with water to a depth just greater than the height of the syracuse watch-glasses which contain the eggs. Water changes can be made in the main dish leaving the eggs undisturbed. When examination is necessary the watch-glasses may be lifted out of the water and placed on the stand of the microscope.

The eggs are about a millimeter and a half in diameter and are perfectly clear and transparent. Cleavage and development is rapid. The first cleavage furrow appears in about an hour at the temperature of the water during spawning. The pulsating heart can be observed on the second day and the circulation is very distinct on the third day. At a general temperature of about 22° C. the eggs hatch on the seventh day. For two or three days after hatching the larvae remain inactive and lie on their sides on the bottom of the dish. In this position the heart action and the course of circulation can be easily studied. Pigment cells are practically wanting at this stage and the blood corpuscles can be seen passing through the finest of the capillaries.

The abundant straw-colored minnow (*Notropis deliciosus*) is found from Michigan, Ohio, Ontario, and New York to Tennessee, westward to the Dakotas, and southwestward to Kansas and Texas. An excellent colored plate of this species is contained in Forbes and Richardson's "Fishes of Illinois," opposite page 137. For a key for the identification of the Great Lakes minnows and a discussion of nomenclature see Hubbs' "List of the Fishes of the Great Lakes, etc."[4]

The straw-colored minnows are found in spawning condition along sandy shores and are usually taken best at night. Little is known of their natural spawning. Working with a seine at night they can be taken in numbers sufficient for experimentation. The fishes can be stripped and the eggs fertilized in the same manner as *Percina*. The spawning season extends a little later than *Percina*, lasting until August 1st at Douglas Lake. The eggs are about a millimeter in diameter and are transparent. Development is very rapid. The first cleavage furrow appears within an hour after fertilization, followed by the second about fifteen minutes later. The eggs hatch about 72 hours after fertilization at temperature 22°–24° C.

The eggs of the common shiner, *Notropis cornutus*, are also excellent material for research. The development is not so rapid, however, as in the straw-colored minnow. They are best taken at night with seine or fine-meshed fyke.

Eggs of the common yellow perch (*Perca flavescens*) are quite satisfactory but the females can not be stripped with any degree of success and the eggs must be secured after they have been naturally spawned and hence the exact time of fertilization can not readily be ascertained. These eggs can frequently be secured from fish hatcheries in April and May in Michigan, and thus are available at an early date.

Reighard[5] worked with a related species wall-eyed pike (*S. vitreum*) which should be satisfactory for physiological purposes.

This list is very incomplete, and no doubt more study will add other species producing suitable eggs for work throughout the spring and summer months.

FLOYD J. BRINLEY
NORTH DAKOTA STATE COLLEGE
CHARLES W. CREASER
COLLEGE OF THE CITY OF DETROIT

[4] Hubbs, Univ. of Mich. Museum, Miscellaneous Publications No. 15, 1926.

[5] Reighard, "Development of the Wall-eyed Pike (*S. vitreum*)," Mich. Fish Comm. *Bull.*, 1: 66, pl. 1-10, 1890, Lansing, Mich.

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